Rec.Models.Rockets FAQ
(Frequently Asked Questions)

Part 11: High Power Construction and Finishing Tips

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This section includes tips and suggestions on various topics having to do with construction and finishing techniques for High Power rockets. Many of the same techniques may be used with Large Model Rockets, as well. Readers are encouraged to read the North Coast Rocketry technical reports on HPR construction and finishing techniques (available from NARTS and other sources).

[Note: This portion of the FAQ is maintained by Jerry Irvine (jjirvine@cyberg8t.com). All comments and suggestions should be sent to him.]

11.1 Do you have any tips for cutting and sealing fins used on HPR rockets?

From: utidjian@remarque.berkeley.edu (David M.V. Utidjian):
To fill the grain in balsa fins and fill in the spirals in body tubes use epoxy. I use HOBBYPOXY "Smooth 'n' Easy" Epoxy finishing resin. For fins it does the trick in one coat... and sands easily... and adds strength to the fins. I use those disposable brushes with the metal handles and brush on a single coat after a preliminary sanding. I then use auto body primer filler in gray and red-brown from spray cans for the entire model. This gives very thin and even coats. I alternate the colors of the coats to show where the low and high spots are. My last sanding before paint is done with 400 grit wet/dry paper and I do this wet... being careful not to get any inside the body tube. [Another good coating-type epoxy is PIC 'Coating Poxy'...Buzz] [NOTE: This is not for kids or the inexperienced!! This technique is used in HPR where the added weight is not a penalty: Buzz]

From Bob Turner (NAR member, not on net):
Bob Turner (the DARS NAR section advisor) suggests using alcohol in smoothing 'coating' type epoxies. The PIC 'Coating Poxy' instructions suggest using your fingers to 'burnish' any surfaces (i.e., fins) filled with the coating poxy. Bob suggests using a VERY soft cloth which has been dipped in alcohol to rub the fins after about 30 minutes (or whenever the epoxy starts to set and is just slightly sticky to the touch). [I followed Bob's suggestion and got MUCH smoother fins over the hand/finger burnishing method...Buzz]

From: jack@rml.com (Jack Hagerty):
When sanding fins, or any other balsa part that you want to be all uniform, stack the parts together, even them up the best you can (you'll be surprised at how uneven those die-cut pieces are!) on the root edge and drive a couple of straight pins through them to hold the stack in registration while sanding. For larger fins, anything over about 2 sq in, use three pins. I find that the pins that come in shirts are just about the right size. The small holes that are left when you remove the pins are easily filled during the sealing/filling step.

From: kaplowro@hccompare.com (Bob Kaplow)
I've found two handy tools for sanding big rockets. 3M makes these sponge-like sanding pads. They are great for conforming to the curves of tubes, nose cones, fillets, etc., and make quick work of fillers. The second is a palm sander, just like Norm uses on TV. Big rockets call for heavy duty solutions. Save the belt sander for airfoiling the fins during construction.

Condensed thread on filleting fins; many contributors:
First, ALWAYS fillet high power fin joints, even fins mounted TTW to the motor mount. This will add strength and improve the aerodynamics of the model. The suggestions for filleting material include:
* 5 - 30 minute thick epoxies
* 30 minute (or longer) thin epoxy mixed with micro-balloons until it has a thick, paste-like consistency; let it thicken some prior to using it
* SIG Epoxilite (warning: this got very mixed reviews)

Always keep a bottle of rubbing alcohol handy when working with epoxy. Dip your finger in the alcohol and run it along the fillet to smooth out the bumps. It was mentioned that a pure epoxy 'topcoat' was necessary on top of the epoxy/micro balloon mixture, although using an alcohol-soaked finger to smooth the micro-balloons might eliminate the topcoat requirement.

Use 30 minute epoxy with microballoons added. Let it sit for a few minutes in the pot so it thickens, and then apply it. The microballoons make it much less runny, so you don't have to keep watching the fillet

to make sure it's not dripping or running around the edges. Also do one side of two fins at a time:

```
        \          /
         \        /     f = fillet, ^ = really bad version of body tube
          \f    f/      / and \ = fins
           ^^^^^^
```

11.2 How do you keep in a high power motor in its mount, but still alow for the numerous lengths in which HPR motors are sold?

From: billn@hpcvaac.cv.hp.com (Bill Nelson)
I make a clip similar to the ones used on model rockets - however, I do not pierce the motor mount tube - I place the front end of the retainer over the front of the tube. It is epoxied/taped in place, just like with a model rocket. I do not rely on spring pressure to hold the clip over the end of the engine. I use several turns of strapping tape - wrapped around the engine or motor mount and the retainer clip. So far, I have never had a problem with an ejected engine.

From: JCook@Epoch.COM (Jim Cook)
Some folks at NARAM 33 suggested drilling a small hole in the side of the flange of the rear nozzle retaining ring [of an ISP reloadable motor casing] to tie the casing to the model. Some might claim this to be "modification of rocket motors not approved by the mfg." I had though I heard Aerotech was going to start doing this themselves, but I haven't seen anything yet.

From: neil@boi.hp.com (Neil Pyke)
I've built #8-32 "t-nuts" into my last couple of rockets and then made sheet metal brackets to hold the motor in. I drill two holes, 180 degrees apart, in the aft centering ring and then press and glue the t-nut into the hole. The screw holds the bracket to the centering ring and I bend the bracket so it hooks over the end of the motor. The t-nut works great but I've made my brackets too wimpy. Those that saw me wandering around just past the flight line at LDRS a couple weeks ago, looking for my ejected motor, will know that I have not perfected my application of this design.

From: Roger.Wilfong@umich.edu (A. Roger Wilfong)
I've used a similar technique with t-nuts and had no problems - yet. I've also tried a coarse thread sheet metal type screw (I'm not sure what they're really called - the threading is about twice as coarse as a regular sheet metal screw) screwed into the rear centering ring at three locations. The centering ring needs to be plywood and you need to carefully drill the correct sized pilot hole for the screw. After 'tapping' the screw into the hole, I took it out and ran a small amount of thin CA into the hole for reinforcement - let the CA set before you put the screw back in the hole or you won't get it out again. This has worked on RMS-29 and while it is not as strong as the T-nuts, so far it has been more reliable than masking tape.

From: soc1070@vx.cis.umn.edu (Tim Harincar)
On the 2 29mm birds I've constructed, I use a clip and a thurst ring. It works like this:

```
   ---:|     |
  =====:|     |====== <- Centering Ring
       :|     |
       :|     | <- motor tube
       :|     |
       :|     |             --:
       :|     |               :  <-Clip made from steel rod
  =====:|     |======         :--
       :
       :--
```

The steel rod has two opposite 90 degree bends, and is run through the centerings and along the motor tube. The idea is to spread the force of ejecting along the top centering ring and to the rest of the motor mount, instead of making the clip do the work. Also, on larger tubes, you can design this so that the clip swivels into place, instead of using spring tension.

The clip then extends 1/4" to 1/2" beyond the end of the tube. You then use this space for the motor thrust ring. The thrust ring is then added to the end of motor. I just usually wind the end of my motor with a bunch of turns of masking tape, but I've heard of people epoxying some other type of ring to the end of the motor.

From: waltr@netcom.com (Walt Rosenberg)
You use a "thrust ring" - several wraps of masking tape on the nozzel end of the motor. This prevents the motor from going up the mount.

Of course, if you use re-loadables (ISP, AeroTech), the nozzel enclosure is latger than the O.D. of the motor mount - in this case, just the tape to keep it from coming out. Of course there are several methods used to keep the motor from kicking - screws and washers, screws and hooks, retaining rings, etc. placed over the ridge on the nozzel end of the motor.

From: pstemari@well.sf.ca.us (Paul J. Ste. Marie)
Typically what you do is wind a ring of masking tape at the end of the whoosh generator of the same thickness as the engine mount tube. This serves as a block to keep the engine from sliding up into the rocket under thrust. Typical widths of tape to use are:

.25"	1/4A-B
.5"	C-E

```
.75"      F-H
1.0"      H-I
1.5"      I-J
2.0"      J-K
```

From: waltr@netcom.com (Walt Rosenberg)
[Referring to the use of different tape widths, above]
1.5" for I-J and 2.0" for J-K may be too wide. You are now going to move the center of gravity further back. You may introduce instability. I've never used more than 3/4" for all my high power launches (H-K).

From: kaplowro@hccompare.com (Bob Kaplow)
My [retainer] hooks look like this:

```
    ----
    |  |  <<- this end slips over lip of bottom reload
    |         closure
    |
    |
    |
____|     <<- this end screwed/bolted onto rear bulkhead

  ^hole drilled here for cap screw
```

The top of the hook wraps over and around the reload closure lip, and can't push out like an Estes clip. Hooks ARE brass. I use stainless cap screws to hold the clips in place - cap screws stay on the end of the tool, unlike other screws. I use T-nuts installed on the back side of the rear centering ring, or threaded brass inserts to retro-fit older rockets.

11.3 Custom Decals for High Power Rockets

The techniques described here could also be used for model rockets. The decals made this way tend to be large and `thick', so this info has been included in the High Power section.

From: soc1070@vx.cis.umn.edu (Tim Harincar):
As a computer graphics person, I have done quite a bit of experimenting with laser printers and making my own rocket art. I mostly stick with clear sticky-back type stocks, they are the cheapest and most available.

I use Fasson brand, and I think its 1.5 or 2 mil. thick. It works good for large models but is a little thick for small scale stuff. It curls right out of the laser while it cools. Don't worry, though. It doesn't distort. This stuff is typically available at most quick print shops. Typically its called Crack 'N Peel.

Toner chips very easily off of the smooth finish, so be careful and as soon as you can, spray on an over coat of clear flat enamel or lacquer. I tape the sheet down to cardboard then spray, Leave it for a day or so. This also makes it lie flat.

I know that blank water transfer stock is available, but its about $3 for an 8.5 x 11 sheet. Use same method as above to preserve the image. This is usually available at model railroad shops.

I have never seen the dry-transfer stuff, but I know its pretty popular with the railroad folks. (that is, the pre-printed stuff).

One other option that I have wanted to try is the heat-transfer colors. Once you have a laser image, you lay a piece of special colored film over the image and heat either with an iron or re-run the sheet through the laser and let the fuser do the work. The color then attaches to the toner.

Most of these colors are metallic, but there are some standard, non-metallic colors as well. Letraset was the first company to market the color transfer stuff.

11.4 I've had several rocket body tubes ruined by the shock cord tearing into the body tube at ejection and making long slits. How can I prevent this?

Many of us have recovered our rockets only to find that shock line has slit ('zippered') the body tube. This happens most often when a very thin shock line is used or when the rocket is traveling very fast when the tubes separate. The following suggestions have been offered to prevent this from happening:

From: barrett@powder.add.itg.ti.com (Stu Barrett)
I built a LOC Caliber a year or so ago. I installed a LOC ejection baffel at the top of the motor mount tube and that worked great. However, I'm in the process of enhancing my model so that it uses the "anti-zipper" technique that is described in the Mar/Apr [1993] issue of HPRM. It combines a fool proof mechanism to eliminate the dredded "zipper effect" and also has a nice effect that no wadding is needed.

11.5 Estes 'toilet paper' recovery wadding strikes me as a bit wrong for HPR rockets. What are some alternatives?

From: jack@rml.com (Jack Hagerty)
Just go down to your local building supply store and get a bale of cellulose wall insulation. This is just shredded newspaper treated in the same fire supressant [as Estes recovery wadding]. A $5 bag will give you enough wadding to last years!

From: jsvrc@rc.rit.edu (J A Stephen Viggiano)

In order to avoid fallout, you might want to put the engine in *before* the [cellulose] wadding, or, for smaller rockets, a sheet or two of regular wadding underneath the fluffy stuff.

Wayne Anthony uses cabbage leaves (you get more leaves per head [than lettuce], and they seem to be a little tougher than lettuce), and I've heard of people using grass.

From: bmcdermo@ix.netcom.com (Buzz McDermott)
I use acoustic speaker insulation. I costs #3 - $5 per bag at Radio Shack. It's reusable, and one bag generally lasts me for dozens of flights. [*Editor's note: This material is not necessarilly bio-degadable or environment friendy. Do not use this type of recovery wadding at any field where remnants might be ingested by live animals. It will kill them. Also, consider tethering fiberglass to shock line to prevent loss.*]

11.6 What are the differences between the various HPR body tube materials used by the most HPR manufacturers?

The most common one is that material used by Estes and later by other suppliers such as U.S. Rockets, LOC Precision, AeroTech, Launch Pad, etc. This material is a spiral wound virgin kraft tube. Virgin kraft is stiffer than recycled kraft and can much more easily withstand flight stresses at a given thickness than recycled tubes as commonly found in household goods.

This material typically has an outer wrapper of "glassine" which makes the tube smooth and accepts paint more easily. It also covers up the thicker tube spirals of the underlayers and makes removing tube spirals with a couple applications of sanding sealer practical.

Another common tube material is that used primarily by Public Missles. It is a spiral wound paper with phenolic resin impregnated into it. This has several advantages such as higher ultimate strength in aero-applications, more waterproof out of the box and being fairly stiff. However this material is also susceptible to cracking due to impacts and has been known to crack during routine slow landings under overadequate parachutes.

A really good material for HPR is used only by Dynacom and U.S. Rockets and is known as G-10 fiberglass. There are several practical variants of this material. One can use either cloth wound or filament wound and the G-10 refers to one supplier's particular classification of a resin they use. Even they use a dozen different resins. Among the glass's uses are "e-glass" and "s-glass". Since one is both more expensive and stronger in ultimate fail tests it is often used as motor casing material. However for airframe applications, cheaper and thinner is better.

Other good but less common materials include cloth wound phenolic impregnated, paper convolute wound phenolic impregnated, exotic composites of kevlar, graphite, etc.

A very common material used (at one's own peril) is recycled paper style tubes such as mailing tubes, paper towel rolls, etc. These must be over 1/8" thick to even be used for HPR at all. Even then they are easy to damage and "unroll" on landing as they typically do not use glue except on the edges. Rocket specific tubes are glued across the entire surface of the superior virgin kraft material.

Plastic tubes can be used but the bonding problems of motor mounts and fins have resulted in these having virtually no adoption among serious model or high power rocketeers. Motor mount tubes must have an insulative element as plastic motor tubes would quickly become the permanent owner of a motor casing.

11.7 How can I strengthen my thick paper (i.e., LOC type) body tubes?

Various composite construction techniques may be employed to strengthen paper body tubes. These same techniques may be used to build scratch body tubes as well. An excellent article on composite construction techniques appeared in the XXXXXXXXXX issue of High Power Rocketry magazine. Another article dealing with strengthening HPR rockets appeared in the XXXXXXXXX issue.

The two most practical methods for strengthening the paper body tubes used by LOC, THOY, etc. are 1) reinforce the tube with couplers for most of its length and 2) wrap the tube with some type of reinforcing layer.

The first option produces a strong tube, but has the drawbacks of high cost (at $2-4 per coupler) and high weight.

The most common material used with the second option is fiberglass cloth. Two ounce cloth is good for use on 2.5 to 4 inch diamter tubes. Five ounce cloth might be used for larger tubes. R.m.r posters have recommended several techniques for applying the fiberglass. Here are two of them:

From: bmcdermo@ix.netcom.com (Buzz McDermott)

1. Sand the tube with 320 grit sandpaper to slightly roughen its surface.
2. Mark a straight line down the length of the tube.
3. Lay out the fiberglass cloth on a flat, smooth surface. Use a square/ straight edge and a SINGLE EDGED RAZOR BLADE to cut the fabric to a rectangle, allowing for at least 1" overlap around the diameter and off each end of the tube to be covered.
4. Lay out and tape together enough wax paper on the floor of your garage, basement,etc., to be larger than the fiberglass cloth in all dimensions. Lay the cloth on the wax paper. Tape the wax paper to the floor (but NOT to the glass cloth).

5. LIGHTLY spray one side of the cloth with 3M 77 adhesive. I mean to put on a QUICK, VERY LIGHT coating of adheasive.
6. Lay the tube down on one edge of the fiberglass, using the line on the tube as a guide to get the tube straight along the glass cloth.
7. SLOWLY roll the tube along the cloth, working out wrinkles with your fingers. The 3M 77 should lightly tack the cloth to the body tube.
8. Once the cloth is on the tube, use thin *orderless* CA to seal the overlap and edges along fin slots and ends of the tube. Using a plastic bag over one hand gently rub the CA into the cloth. Also CA any wrinkles that are left. When the CA dries you can use the single edge razor to trim off excess cloth at the ends, feather sand the overlap joint (with 320 grit), cut out fin slot openings, and sand down or slice off any wrinkles in the cloth.
9. Brush on 20 minute 'finish cure' epoxy. Bob Smith 'Coating Poxy' and Hobby Poxy 'Smooth N Easy' are good choices. Completely cover the entire cloth surface. Be sure and gently work the epoxy into the cloth. You want the cloth soaked and the epoxy soaking into the body tube.
10. About an hour after you finish, the epoxy should be getting real 'tacky'. Soak some rubbing alcohol into a clean, lint free cloth and use that to lightly 'buff' the epoxy. This will help smooth the coating and get rid of air bubbles.
11. After 24 hours, sand with 240 grit wet-or-wry, WET, until smooth. You are now ready to prime.

Two additional notes:

1. With lighter cloth (3/4 up to 2 oz), I sometimes soak cyano into the entire cloth surface. I then sand with 320 grit VERY LIGHTLY. I find I use much less epoxy and end up with a lighter rocket. This is a good technique when weight is critical.
2. Always were latex gloves when working with epoxy. People do develop nasty reactions to this stuff over time.

From wolf@netheaven.com (Wolfram v.Kiparski)

When using 3/4 oz. cloth, I find it easiest to first paint epoxy (thinned with a little laquer thinnner) on the body tube and then lay the cloth onto the tube. The cloth readily "wets out" when it touches the epoxy, and adheres to the tube without curling up. The cloth can be gently arranged and gently brushed to smooth out the wrinkles as you wrap it around the tube. Extra epoxy can be dabbed on as needed.

For 3/4 oz. cloth:

1. Cut the cloth to size first. Cut the cloth slightly oversize so that it is a little longer than the tube, and will overlap if wrapped around the tube.

2. Mix your favorite epoxy and add about 5% laquer thinner. Paint this onto your body tube with a china bristle brush. I use a 1.5 inch brush. Thinning the epoxy makes it spread easier, and will help keep lightweight cloth from distorting and wrinkling. It will also cause you to use less epoxy.

3. While the epoxy is still "wet," drape one end of the cloth onto the body tube. Use your brush to smooth the cloth out. Brushing in only one direction will help avoid wrinkles. Roll the tube slightly as you smooth the cloth onto the epoxy-covered tube. The cloth will pick up enough epoxy to wet-out. If it doesn't, add a dab of epoxy to help it along. You can free both hands by placing the body tube over a long wooden rod like the kind used for closet hanger rods. Support the rod at both ends kind of like a giant toilet paper dispenser.

4. 3/4 oz. cloth will stick to the body tube and tend not to lift up before the epoxy has cured. Be careful not to brush too vigorously when overlaping the cloth as you finish applying it. You might wrinkle the bottom layer of the overlap, and experience a great deal of frustration.

5. After the epoxy has cured, lightly wet sand with 220 grit sandpaper. Fill in any low spots with spot putty and sand smooth. A few coats of primer will fill in the weave of 3/4 oz. cloth, especially if you lightly wet sand with 320 grit between coats.

With a little practice, this technique is easy to do, and adhesives other than epoxy are not required.

From: dave@ddave.com ('Dangerous' Dave)
[Dave had the following comments about the above described technique. Dave is an expert in the use of composites, fiberglass and laminating techniques]
When the glass is fully cured, you can sand the lap joint till it feathers into the ajoining surface. Any irregularities can then be filled with a polyester filler (Bondo) and spot putty to blend the surface so that it is unnoticable.

Don't use an adhesive to tack the glass in place. It will prevent the resin from soaking into the fabric and will effect the physicals of your epoxy. Cut your fabric to size allow and inch or so overlap that you can trim off later. Wet your surface and then drape the fabric on to it. Then stipple the resin into the fabric with a china bristle brush. Don't use a paintbrush that is made from synthetics, i.e.: nylon, polyester, ect.. The epoxy and/or your cleaning solvent will disolve your brush and it may react with the resin.

Be sure and read my Safety Document on handling composite materials before you do any of this.

You will get your best adhesion by completely removing the glassine. Since resin can't penetrate it and will not bond well, you must remove it in order to take advantage of any strength gains you get from applying glass.

Visit my web and ftp sites for some more info on laying glass. FibreGlast at: http://www.fibreglast.com has a very good section on composite techniques.

[*Editor's note: If you're going to work with fiberglass, epoxies, or carbon fiber, check out DDave's web page, http://www.ddave.com/*].

11.8 Is there any way to retrofit my existing rockets to have some type of positive retention system?

From: billn@PEAK.ORG (Bill Nelson):
Well, you can reinforce the aft ring a bit, then use the screw-in threaded connectors that are available.

From: silent1@ix.netcom.com (The Silent Observer):
Drill a hole on each side, and install a Molly (R) or similar "drive fastener" or expansion fastener -- the kind used for hollow walls and doors. Do this with a dowel or motor casing in the motor tube, so the little metal "legs" on the fastener don't punch through the tube; you'll find these are about as strong as a blind nut, install from the front, don't cost much more (if at all), accept standard threads (and come with a screw!), and look neater. One thing to watch, though; the threads in the fastener strip pretty readily (they're aluminum) and they're the devil to remove if you do strip one.

From: jsivier@ux1.cso.uiuc.edu (Jonathan Sivier):
I retrofitted blind nuts on a couple of my rockets using the anchor bolts that are available at most hardware stores. These are a metal tube with threads on the inside and slits along part of their length. You drill a hole in your bulkhead, push the bolt unit through and tighten the bolt. As it tightens the tube expands at the slits to push against the back of the bulkhead. It also has a lip on the front so the anchor is firmly, uh, anchored. :-) With a little epoxy under the lip it becomes a very strong mount for motor retention devices. They have different sizes for different thicknesses of material, from 1/8" up. They may take up a bit more room than the blind nuts, but if the rocket is already built they are a great way to make this improvement.

From: kaplowro@hccompare.com (Bob Kaplow):
Use threaded brass inserts, and a drop of thin CA to keep them in. They don't have the large lip on the back, so it won't be as strong, but my first 3-4 HPR models were done this way. Now I put blind nuts (also called T nuts) in all my larger rockets. I even use them in motor mounts where I have the room. DuBro makes some VERY SMALL 6-32 T-nuts that fit most adapters that have a plywood ring. I've yet to come up with a retainer for the heavy cardboard tube style adapters.

From: c72500@aol.com (Gary ??, C72500)
If you have already assembled the rocket, look for a "thinsert" and installer tool. This is basically a threaded rivet -- drill a hole in the centering ring, put nose of tool (wiith insert threaded on) and squeeze - permanently installed threaded insert! I have used this to retrofit every rocket I have built, and have yet to lose an insert or a motor. Installer and inserts are available through a company called Northern via catalog - runs about $13.

11.9 All these high power motors are different sizes. How do I hold them in? What do I use for a motor block and where should I put it?

From: jackson@sn3.jsc.nasa.gov (Al Jackson)
For mounting and retaining HPR motors I have this suggestion, especially with PML models. See if you can let a good one inch of motor mount protrude from bottom of model. Then when using a reload motor, besides using a tape friction fit, put a wrapping of strapping tape around the end enclosure and wrapped also around the piece of motor mount sticking out.

From: jjirvine@aol.com (Jerry Irvine)
Perhaps i'm just tired of seeing people reinvent the wheel to non-round shapes, but I have found that:

1. There is no need for thrust rings inside rockets of any power or weight. The application of a masking tape thrust ring on the nozzle end of the motor of adequate width for motor thrust is always adequate, to the point where a fiberglass or metal one is better.
   a. 1/4" wide masking tape is often used for 1/4A-F motors with thrust levels under 40 newtons.
   b. 1/2" wide masking tape is often used for 1/4A-J motors with thrust under 200 newtons.
   c. 3/4" wide masking tape is often used for F-K motors with thrust under 600 newtons.
   d. 1" up to 1000 newtons, 1.5" up to 2000 newtons, then above that a structural ring at the rear of the motor.
2. With the above system one can add an external motor hook with NO protruding rear thrust block, extended out the rear the exact width of the masking tape you most prefer. The hook should typically be metallic and bonded to the outside with epoxy for maximum strength and instead of protruding hooks, they can fan out to the side for better bonding strength.

From: kaplowro@hccompare.com (Bob Kaplow):
You want to install blind nuts on the BACK side of the aft centering ring, before the mount is installed in the rocket. That way it can't pull thru. [Epoxy a little around them] to hold them in place when not bolted in. The

screws go into these threaded holes, and hold in whatever clip you are using. I personally prefer cap screws and an allen wrench to machine screws and a flat blade screwdriver. The allen wrench holds the screw while I'm installing it at a funny angle.

From: bmcdermo@ix.netcom.com (Buzz mcDermott):
You can use blind nuts (also called T-nuts), available from many hobby shops and most hardware stores. Two or three size 4-40 work fine for up to 38mm motor mounts. For anything bigger I would use two or three size 6-32 nutes. For three and four motor clusters that don't have a central motor you can expoxy a balsa or spruce strip into the central gap between the motors. Drill a 1 inch deep hole in the exposed end of the strip appropriate for epoxying in a 2.5 inch length of 1/8" threaded rod. Use a washer and nut to retain all three or four motors from a central point.

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